Depleted Oxygen Levels in the Nearshore Waters of Northern Washington

Mary Sue Brancato, Lindsey Milonas, David Kirner and Ed Bowlby: Olympic Coast National Marine Sanctuary
Contact: mary.sue.brancato@noaa.gov. www.olympiccoast.noaa.gov

Abstract

In 2004 the Olympic Coast National Marine Sanctuary (OCNMS) initiated dissolved oxygen (DO) monitoring to determine the timing, severity, and extent of depleted oxygen levels along the Olympic Coast. In 2004 and 2005, CTD-DO casts were taken off the RV Tatoosh biweekly between June and early October along 3 cross-shelf transects at Cape Alava, Teahwhit Head and Cape Elizabeth. In 2006 OCNMS deployed seasonal moorings with continuous CT-DO recorders approximately 1 meter off the seafloor along two of these transects and continued casts along the third transect, and deployed continuous recorders along all three transects in 2007, extending the transects to 100m with the collection of point data during monthly servicing.

No measured oxygen levels recorded in 2004 or 2005 could be characterized as hypoxic (<2mg/L). However, in 2004, near hypoxic conditions (<3mg/L) were routinely measured. In 2005, a few near hypoxic events were measured at >50m depths off Cape Elizabeth in May-July.

In 2006, hypoxic conditions occurred in May and June as far north as Cape Alava and as far south as Cape Elizabeth. Hypoxic conditions were more extensive at Cape Elizabeth, extending into shallower and deeper waters and for longer durations. Data co-occurring with fish and crab mortality events reported by the Quinault Indian Nation in late July 2006 near Cape Elizabeth are supported by DO concentrations that got as low as 0.0245 mg/L between 16 and 30 July 2006. No observations of invertebrate or fish mortalities were reported by observers during the May, June, August, September or October 2006 hypoxic events.

The data for 2007 is currently still being collected and processed. From early May through mid August 2007, hypoxic conditions occurred only at the southern-most station (Cape Elizabeth). Hypoxic conditions occurred briefly in mid June at the Cape Elizabeth 65m station, at the end of June into early July at the Cape Elizabeth 42m station, and in early July at the Cape Elizabeth 15m depth station. The lowest concentration measured was 1.52 mg/L. More extensive hypoxic conditions occurred in mid July and on into August, as indicated by DO concentrations as low as 1.0-1.2 mg/L at all three Cape Elizabeth stations from mid to late July at Cape Elizabeth 42 and 65m stations, moving into the 15m station in August. No observations of crab or fish mortalities were reported during this time frame.

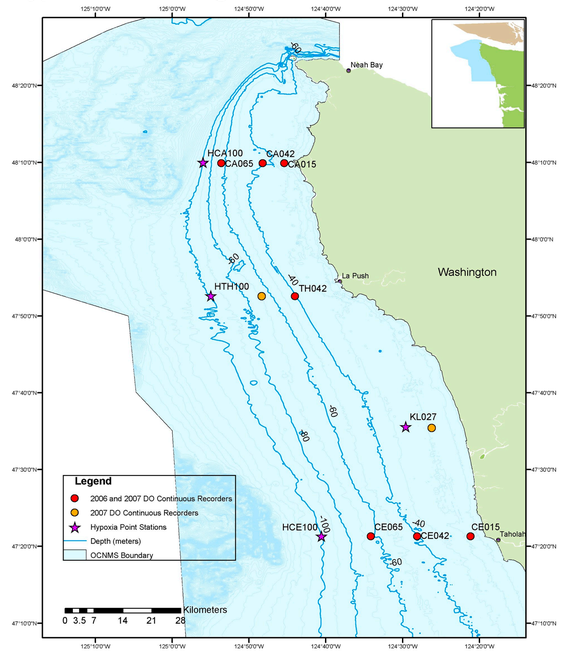
Introduction

Recent reports indicate low DO levels occur periodically in nearshore marine waters along the coast of Oregon and Washington causing fish and invertebrate mortality. Low oxygen along the seafloor in deeper waters is a normal event, but not so in nearshore waters of 65m and less. The low oxygen events on the outer coast are caused by northerly coastal winds moving surface waters offshore in the spring-summer, bringing cold, low oxygen, nutrient-rich waters towards the coast and to the surface in upwelling events. The nutrient rich surface water promotes phytoplankton blooms that soon die back, sink and decay, further lowering oxygen levels. The decay of the phytoplankton lowers oxygen levels until the winds change or cease allowing the water to mix. Although upwelling is a normal event along our productive coast, several scientists have predicted changes in the oceanography of the northeast Pacific, which include an acceleration of upwelling events. This acceleration or shorter time frame between upwelling events could be responsible for the fish and invertebrate mortalities off Washington and Oregon in 2006, in which depleted oxygen occurred for longer durations and in shallower water.

Purpose and Objectives

Since 2001, the OCNMS has periodically observed crab mortalities or received reports from beach walkers, commercial crabbers and coastal biologists with the tribes, federal and state agencies of dead crab and bottom fish littering the shoreline most often between Kalaloch and the Copalis River, where the shelf is wide; however, on occasion, reports are received as far north as Makah Bay. Early reports of mortalities were primarily of Dungeness crab, which led us to initially investigate potential disease vectors. Repeated mortality events, often during a similar time frame, and multi-species occurrences led to our interest in investigating the role of depleted oxygen. Thus, in 2004, the sanctuary began monitoring DO levels to determine the timing, severity, and extent of depleted oxygen levels along the Olympic Coast.

Hypoxia Monitoring Locations



Methods

In 2004 and 2005, temperature, salinity and DO water column profiles were taken approximately biweekly between June and early October along three cross-shelf transects at Cape Alava (CA), Teahwhit Head (TH) and Cape Elizabeth (CE), (see map). Stations were positioned at 10m contours between 10 and 100m in depth. These profiles represent point data, only providing measurements at one point in time on a single day. In 2006, OCNMS installed 4 continuous recorders each along 2 of these transects in order to obtain daily oxygen data throughout the summer season at approximately 1m off the sea floor. The 100m moorings were abandoned after interactions with fishers but point sampling continued at these stations during our approximate monthly mooring servicing events. As funds became available, the Teahwhit Head transect has been equipped with continuous recorders and late in the 2007 season, a continuous recorder was deployed at 15m depth off Kalaloch (KL). In addition, in 2007 an expanded hypoxia monitoring program was implemented to try to define the extent of depleted oxygen when hypoxic conditions occur at the time of servicing, or crab and fish mortalities are reported.

2006 Cape Elizabeth 15m Station Continuous Bottom Data

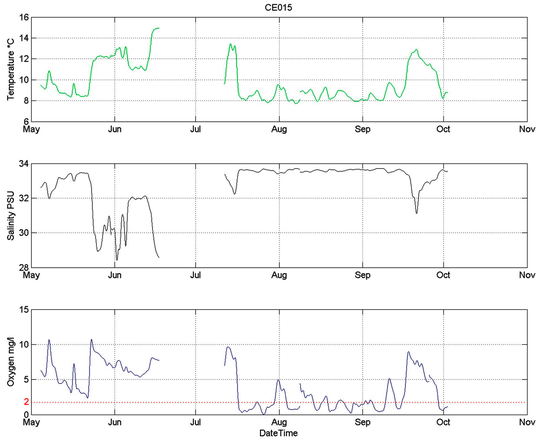


Table 1. 2006 Hypoxic Conditions Measured Using Continuous Recorders

Station	Dates where hypoxic conditions were recorded (DO <2 mg/l)	Dates where near hypoxic conditions were recorded (DO <3mg/l)	Minimum DO recorded (mg/l)	Dates of data collection by moored instrument	Data Gaps
CA015	None	None	3.9485	May 3 to Sep 26	Jun 18 - Jul 6
CA042	Sep 29 - Oct 3	Jul 28 - 30; Aug 3 - 10; Aug 14 - 24; Aug 27 - 31; Sep 2 - 4, Sep 8 - 17; Sep 24 - Oct 3	0.7437	May 3 to Oct 03	Jun 19 - Jul 18
CA065	Jun 23 - 24	Jun 9 - 13; Jun 18 - Jul 3; Jul 10; Jul 16 - 18;	1.9437	June 6 to Jul 18	None
CA100	None	None	3.2817	July 6 to Jul 07	None
TH042	Sep 21 - Oct 2	Aug 20 - 21; Aug 25 - Sep 2; Sept 4 - 18; Sep 21 - Oct 2	0.1829	August 17 to Oct 02	None
CE015	Jul 16 - 30; Aug 3 - 8; Aug 13 - Sep 9; Sep 13 - 15; Sep 29 - Oct 2	May 21 - 22; Jul 16 - 30; Aug 3 - 31; Sep 1 - 9; Sep 12 - 16; Sep 28 - Oct 2	0.0245	May 4 to Oct 02	Jun 18 - Jul 10
CE042	Jun 11 - 12	May 11 - 12; May 16 - 23; Jun 8 - 13	1.9205	May 4 to Jun 18	None
CE065	May 31 - Jun 1; Jun 7 - Jul 11; Aug 8 - Oct 2	May 30 - Jul 11; Aug 8 - Oct 2	0.0837	May 30 to Oct 02	July 12 - Aug 7
CE100	May 31 - Jun 6; Jun 13 - 14	May 30 - Jun 15	1.7560	May 30 to Jun 15	None

Table 2. 2006 Hypoxic Conditions - Point Data - Measured Using CTD

StationID	Dates Sampled	Dates where "near hypoxic" (<3mg/l) conditions were found	Depths in meters where "near hypoxic" (<3mg/l) conditions were found
TH030	June 7, June 20, July 6, July 18, Aug 3, Aug 17	July 6	23 - 26
TH035	June 7, June 20, July 6, July 18, Aug 3, Aug 17	none	
TH040	June 7, June 20, July 6, July 18, Aug 3, Aug 17	none	
TH050	June 7, June 20, July 6, July 18, Aug 17	none	
TH060	June 7, June 20, July 6, July 18, Aug 17	June 7	54 - 55
TH070	June 7, June 20, July 6, July 18, Aug 17	June 7	61 - 68
		August 17	66 - 67
TH080	June 7, June 20, July 6, July 18, Aug 17	June 7	66 - 77
		August 17	61 - 77
TH090	June 7, June 20, July 6, July 18, Aug 17	June 7	68 - 88
		August 17	66 - 87
TH100	June 7, June 20, July 6, July 18, Aug 17	June 7	64 - 97
		June 20	83 - 97
		August 17	Not Recorded

NOTE: no hypoxic conditions (<2mg/l) were found at station TH in 2006

Photo Credit: Northwest Indian Fisheries Commission - Debbie Preston, July 2006, Point Grenville Beach

Results/Conclusions

Hypoxia is often defined as DO below 2mg/L. However, biological stress induced by low oxygen is seen at levels as high as 4-4.5 mg/L. The Washington Department of Ecology defines DO levels below 3mg/L (about 30% saturation) as "near hypoxic".

- No measured oxygen levels recorded in 2004 or 2005 could be characterized as hypoxic (<2mg/L).
- In 2004, near hypoxic conditions (<3mg/L) were routinely measured near the seafloor in July at the deeper water sampling sites (>70m) along all three transects, and at Cape Elizabeth at all stations (10m-100m) in June and July and at deeper stations in September and October.
- In 2005, only a few "near hypoxic" events were measured – strictly at deeper water sampling stations (>50m) off Cape Elizabeth during point sampling in May, June and July.

In 2006 and 2007, with the installation of continuous recorders at 6 to 9 stations from May into October, a more complete picture was obtained and hypoxic conditions occurred for longer durations, in shallower depth and over a greater area in 2006. Preliminary data from 2007 reveals perhaps a more typical year, with oxygen levels lower and for longer periods in the late summer and possibly into fall in the southern portion of the sanctuary where the shelf is wider. Thus far, 2007 concentrations have not dropped to those observed in 2006 during the period of reported crab and fish mortalities.

- In 2006, hypoxic conditions occurred in June and again in September - October as far north as our northern-most station at Cape Alava and as far south as our southern-most station at Cape Elizabeth in the bottom waters at the 42 and 65 meter depth stations. (Tables 1 and 2)
- At Cape Elizabeth the hypoxic conditions in 2006 were more extensive, extending from shallow waters (15m station) that are generally well mixed, to the 100m station throughout the summer months and on into October when the moorings were retrieved.
- Data co-occurring with the fish and crab mortality events reported by the Quinault Indian Nation in late July near Cape Elizabeth are supported by DO concentrations as low as 0.0245 mg/L between 16 and 30 July 2006.
- In 2007 hypoxic conditions occurred briefly in mid June at the Cape Elizabeth 65m station, at the end of June into early July at the Cape Elizabeth 42m station, and in early July at the Cape Elizabeth 15m depth station. The lowest concentration measured was 1.52 mg/L. Invertebrate (crab) mortalities were reported to OCNMS as far south as Roosevelt Beach and as far north as Kalaloch Beach in late June. Although these may have been molts, the observers are provided information on how to distinguish a molt from a dead crab, but their observations during this mortality event were not confirmed.
- The expanded monitoring has been triggered one time thus far in the 2007 season, during the mid-August servicing of the Cape Elizabeth and Kalaloch moorings when CT-DO casts taken indicated DO less than 2mg/L. Additional casts were taken north of the continuous recorders to determine the extent of depleted oxygen. Due to weather constraints, casts were not taken south of Cape Elizabeth. Expanded monitoring indicated that hypoxic conditions occurred at Cape Elizabeth and Kalaloch but not at Raft River between these two locations.

- No observations of invertebrate or fish mortalities were reported during any of the other 2006 or 2007 hypoxic events, which could be due to a variety of reasons, e.g.,

  - the events were short in duration or limited in extent;
  - DO concentration did not get as low as those measured in July 2006;
  - no observers were on the beach to report during the hypoxic time frames;
  - the mobile organisms had moved out the area previously;
  - the carcasses were transported elsewhere, etc.

An obvious question is how and what organisms will be affected by low oxygen and what is their tolerance?

To improve our understanding of future hypoxic events and their ecological impacts, OCNMS hopes to continue its mooring program with additional continuous records and eventually year round moorings with real-time data transmission. In addition, we continue to expand our partnerships with British Columbia, Washington and Oregon. With a more extensive monitoring network, OCNMS and its partners will be able to piece together the picture of what is occurring off the coast.

Photo Credit: Quinault Indian Nation, July 2006, Point Grenville Beach